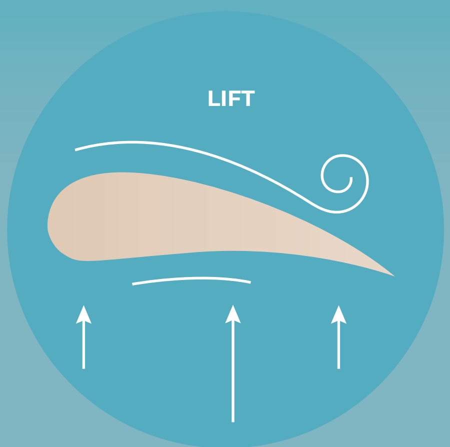
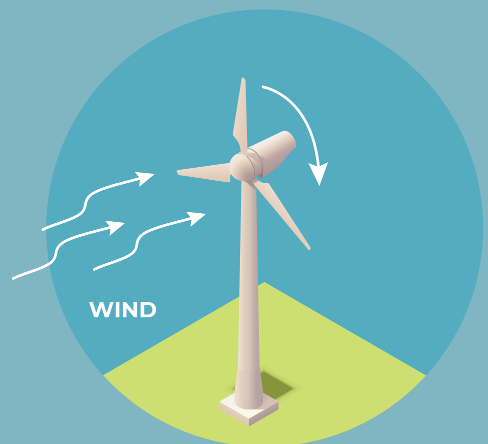
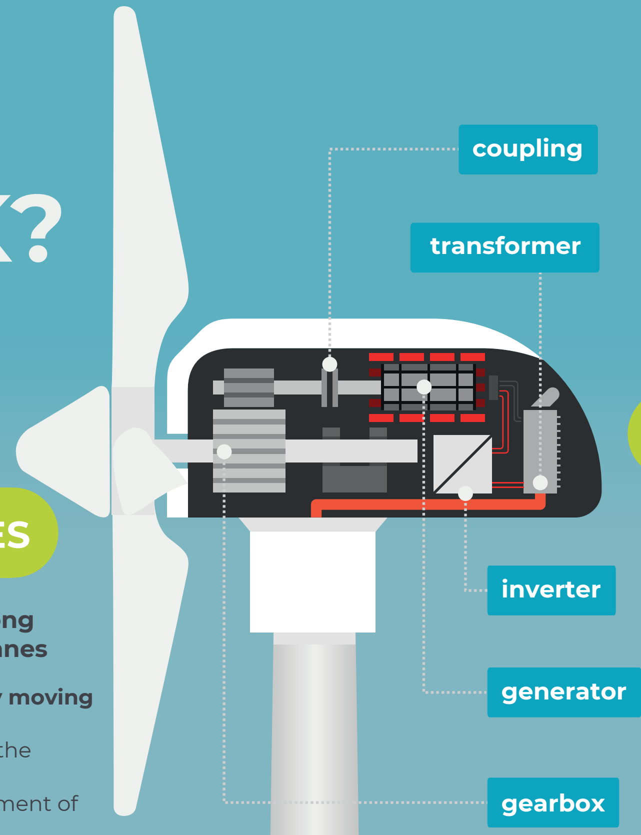
HOW DO WIND TURBINES WORK?







1 ROTOR BLADES

Blades are 45–65 metres long
Each weighs about ten tonnes

There are two types of energy moving the blades:
1. aerodynamic lift provided by the shape of the blades
2. thrust provided by the movement of the air

What causes aerodynamic lift?
The blades are similar to airplane wings, flat on the bottom, curved on the top. As air travels along the blade, it moves over a shorter distance on the bottom ("walks"), than on the top of the airfoil where it needs to travel longer in the same time ("runs"), which creates higher air pressure on the bottom side, pushing the blade up, and lower pressure on the top side.

- When wind is blowing, the blades spin at around 10–12 turns per minute. The tips of the blades can reach speeds of up to 300 km/h.
- The turbine adjusts the angle of the blades depending on wind speeds to harness as much of the energy provided by the horizontal movement of air as possible
- The energy of flowing air is turned into a rotating movement through thrust and aerodynamic lift

MET

Weight of the nacelle: 100–120 tonnes

The nacelle is the hammerhead-shaped box on top of the tower which houses the equipment that turns kinetic energy into electric power, including the gearbox, the generator, the inverter, and the transformer.

The nacelle can also rotate according to wind direction, so that always faces directly into the oncoming wind, which then hits the blades at a right angle.

2 THE NACELLE

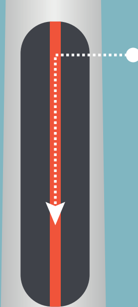
Energy conversion inside the nacelle:
The blades spin the shaft of the turbine at relatively low speeds. This rotating shaft connects directly to the gearbox which steps up the shaft speed to 1,600–2,200 rpm, a more than hundred-fold increase. The rapidly spinning drive shaft is coupled to the generator through a clutch mechanism, which provides a flexible link between the gearbox and the generator to absorb or dampen the impact of potential wind blasts. Power production starts in the generator, which turns kinetic energy (rotating movement) into electric power.

The generator produces direct current (DC) at a voltage of 600 V. Since only alternating current (AC) can be fed into power transmission grids, inverters are used to convert DC into AC.

Due to transmission losses (which are inversely proportional to voltage), electric power generated in the nacelle is transformed to a voltage of 20–35 kV to reduce these losses.

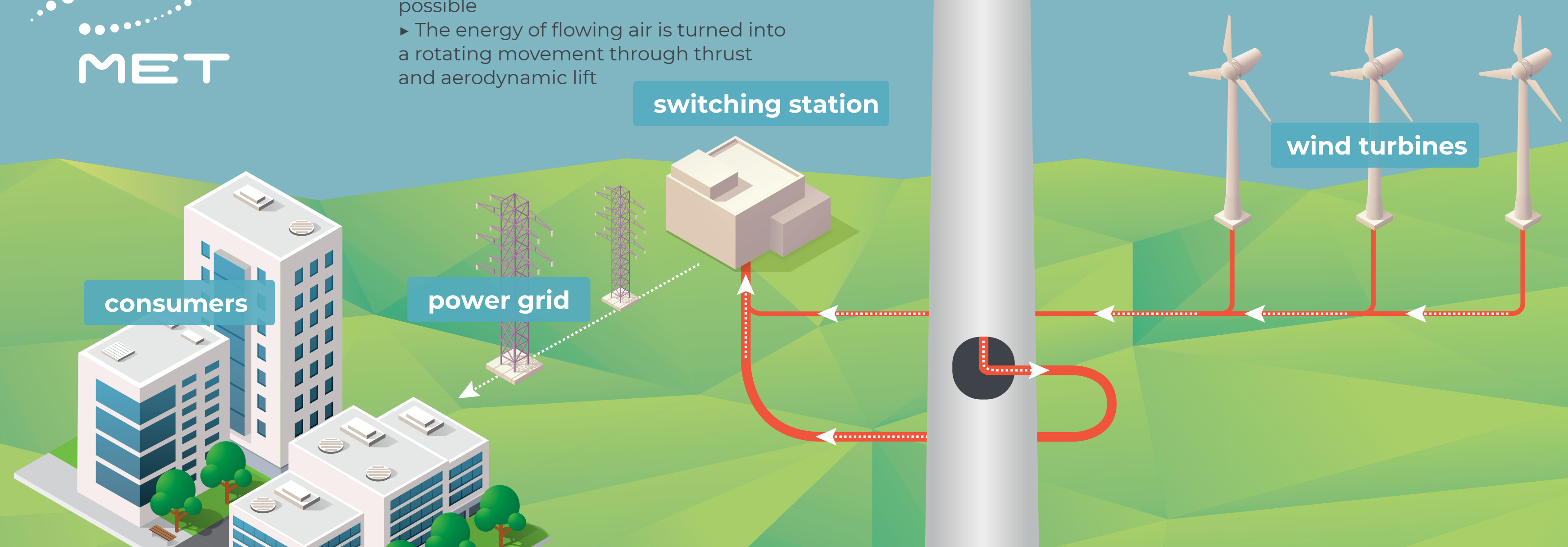
3 THE TOWER

Towers are 80–120 metres high
(equal to a thirty-storey building)



The power generated in the nacelle is transported via cables to the ground level, where it is fed into an on-site substation. Several wind turbines can be connected to a single substation.

The on-site substation is connected with a single generation tie transmission line to either the national power grid or to a grid substation grid which connects to the national grid.



- **Offshore towers: 3–5 MW capacity** Can be built lower with heights around 60 metres. There is no need to reach the higher layers of air as wind speeds are adequate even lower down.

- **Onshore towers: 2–4 MW capacity** A typical household uses about 2400–4000 kWh of electricity a year. A 3 MW capacity turbine produces that amount in about an hour.
2 MW turbines, the most common type in Hungary, provide enough energy to supply 1,200 households for a year.

Cool, damp air is the most favourable for the purposes of power generation: it has a bigger mass, which means it exerts more force on the rotor blades. Wind speeds of at least 12 km/h, and not more than 90-100 km/h are needed for power generation. In winds stronger than that the turbine shuts itself down and turns away from the wind. In Northwest Hungary, the area with the largest number of wind turbines, wind speeds average 6.3 m/s, or 22.7 km/h.

The capacity of wind turbines can be boosted by:
- making the blades longer (blades today can reach up to 100 m in length)
- technical modifications (on the gearbox or generator)